DIURNAL VARIATIONS IN HUMIDITY.

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[Dated Weather Bureau, Tampa, Fla., July 29, 1919.]

Attention has recently been called to the low relative humidity readings at Tampa for the local mean noon observation. These for 1918 averaged considerably lower than at the other Florida stations and, in fact, corresponded more closely to the records of stations in the western plains. That this condition is a fact is shown by the consistency of the hygrograph records during the years 1915 to 1918. Moreover, many persons who have lived in the northern States have remarked that the high temperatures here are more comfortable than similar temperatures at the places from which they came. Table 1 gives relative humidity averages for the local noon observations at the Florida stations for the year 1918.

TABLE 1.

Station.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Tampa	59	59	54	52	46	55	56	54	57	58	53	60	55.3
Jacksonville	59	68	60	58	55	59	60	57	62	72	65	72	62.2
Miami	61	69	62	63	65	69	69	68	72	74	63	68	66.9
Key West	70	69	63	66	67	68	66	65	68	74	65	71	67.8
Pensacola	71	78	74	78	71	66	69	74	70	81	73	76	73.4

Data obtained from bihourly hygrograph records being available from August, 1914, to December, 1918, diagrams and tables have been prepared in the same shape as figures 1, 2, 3, 4, and 5, and Table 4, of SUPPLEMENT No. 6, MONTHLY WEATHER REVIEW, and so a comparison may be made. None of the stations given in Table 4, SUPPLEMENT 6, is in the South, and the only one on the seacoast is San Francisco, which has an entirely different climate from Tampa. For this reason the data for Tampa should be an important addition to our knowledge of humidity conditions.

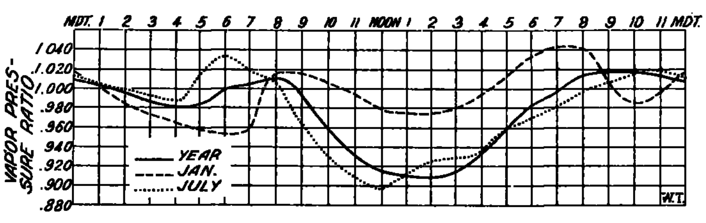

FIG. 1.

From humidity readings at the regular morning and night observations, and from the rainfall averaging nearly 50 inches a year, it might be supposed that Tampa has a very moist climate. The regular observations, however, are taken at hours when the humidity is quite high. The water from the rains does not stand to evaporate, but rapidly disappears in the sandy soil, the surface of which is soon dry.

There are probably several contributing causes of the unexpectedly low humidity readings during the middle of the day. The most obvious is the diurnal range in temperature. During the summer the minimum temperatures run lower than might be expected in the latitude of Tampa, while during the winter the maximum temperatures are higher. For the year 1918 the mean diurnal ranges in temperature for the Florida stations were: Tampa, 17.4°; Jacksonville, 14.8°; Miami 11.6°; Key West, 10°; Pensacola, 12°. Other things being equal, the greater the range in temperature the greater will be the range in relative humidity, and the lower will be the readings near the time of maximum temperature.

The greater range in temperature at Tampa, is partly due to the low elevation of the thermometers. At Tampa the height is 79 feet above ground; at Jacksonville, 209 feet; at Pensacola, 149 feet. At Miami the elevation is 71 feet, and at Key West only 10 feet, but Miami has the ocean in the direction of the prevailing, and nearly constant, wind, while Key West is surrounded by water. Hence the range in temperature at these two stations is lessened by oceanic influence.

The minimum temperature is largely determined by the dewpoint. At Tampa the average dewpoint taken from the regular a. m. and p. m. observations for 30 years, is less than a degree below the average minimum temperature. If the dewpoint and the vapor pressure (obtained directly from it), did not change during the day, the low relative humidity in the middle of the day would be completely explained by the range in temperature. But there is actually a fall not only of the relatively humidity, but also of the absolute humidity as shown by the vapor pressure. Of course, the lower the vapor pressure, the lower will be the relative humidity, the temperature being the same. There is also a fall at some of the other Florida stations, but the fall at Tampa is much greater, as shown by Table 2.

TABLE 2.—*Vapor pressure ratios (vapor pressure at local mean noon observation divided by mean vapor pressure at a. m. and p. m. observations) year 1918.*

	Tampa.	Jacksonville.	Miami.	Key West.	Pensacola.
January	0.980	0.978	1.027	1.033	1.039
February	0.996	1.045	0.992	1.003	1.007
March	0.943	0.977	0.996	1.008	1.010
April	0.929	0.952	0.977	1.033	1.012
May	0.886	0.904	0.998	1.046	0.939
June	0.907	0.923	0.991	1.020	0.977
July	0.927	0.949	0.983	1.025	0.996
August	0.929	0.917	0.994	1.010	1.010
September	0.942	0.925	1.024	1.000	1.039
October	0.938	0.947	1.021	1.010	1.040
November	0.967	1.005	0.965	0.986	1.055
December	1.019	1.028	1.023	1.024	1.051
Year	0.947	0.962	0.999	1.016	1.015

The use of the vapor pressure ratio instead of the actual vapor pressure gives equal weight to the data. and enables a comparison to be made of winter and summer months, and of one station with another, regardless of the actual vapor pressure. This ratio is obtained by dividing the vapor pressure for any given hour by the mean of the 8 a. m. and 8 p. m. (seventy-fifth meridian time) vapor pressure for the same month. (SUPPLEMENT 6, MONTHLY WEATHER REVIEW, pp. 10, 11.)

We may conclude that the low relative humidity at noon at Tampa is due (1) to the great diurnal change in temperature, and (2) to a diurnal range in vapor pressure or absolute humidity, which shows a minimum in the middle of the day. (Table 4 and fig. 2.)

The absolute humidity, or vapor pressure, is influenced materially by the direction and velocity of the wind, and the character of the surface, land or sea, whence the wind blows. A wind from the land would have a smaller moisture content than one from the sea, and the effect of either would be greater during the day than during the night, on account of higher velocity. To investigate this question, the average vapor pressure at noon observations in 1918, was tabulated in connection with the prevailing wind direction from 11 a. m. to noon, the noon observation coming at 11.30 a. m., ninetieth meridian time. In this tabulation, January, February, March, and December were considered as winter months, and June, July, August, and September as summer

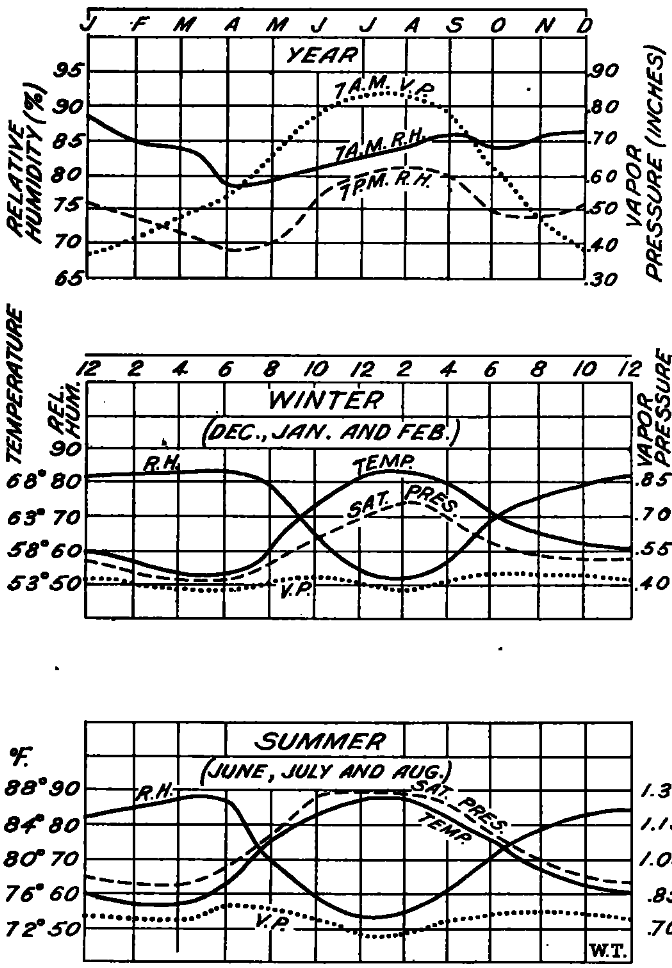

FIG. 2.

months. The frequency of each direction was calculated as a percentage of the total number of observations.

TABLE 3.

	N.	NE.	E.	SE.	S.	SW.	W.	NW.
Winter:								
Mean vapor pressure...	0.277	0.253	0.486	0.518	0.535	0.512	0.400	0.285
Per cent of direction...	12	11	9	10	31	12	3	12
Summer:								
Mean vapor pressure...	0.619	0.637	0.669	0.700	0.706	0.720	0.743	0.667
Per cent of direction...	4	27	6	10	20	29	2	2
Year:								
Mean vapor pressure...	0.372	0.541	0.563	0.607	0.592	0.642	0.464	0.369
Per cent of direction...	7	24	8	9	24	18	4	6

Tampa is so situated that winds from the southeast, south, southwest, and west come from off water surfaces. The table shows that these winds have a greater moisture content than the winds from the other directions, and it also shows that they were slightly more frequent for the noon hour, being recorded 55 per cent of the time. At Miami and Pensacola, the winds are reported to be from off the water 90 per cent of the time, and at Jacksonville, although the percentage is not so great as that, it is considerably greater than at Tampa. Moreover, the winds are of greater force at the other stations, the average wind velocity for the noon hour at Tampa being 8 miles per hour; at Miami 11; at Pensacola 13; and at Jacksonville 13. The greater frequency and higher velocity of the ocean wind at the other stations might account in part for their greater humidity.

However, examination of the prevailing wind directions at all hours of the day at Tampa, shows that ocean winds are considerably more frequent during the middle of the day than at night, and if continental winds were the sole cause of the lower vapor pressure, the minimum might be expected to occur at night rather than during the day.

The diurnal march of vapor pressure at Tampa (Table 4 and fig. 2) shows a curve with two maxima and two minima. For the year as whole, the curve is quite smooth, showing maxima at 8 a. m. and 10 p. m., and minima at 4 a. m. and 2 p. m. The extreme range in actual vapor pressure is 0.062, which is 11 per cent of the average vapor pressure for the 12 bihourly means. The January curve shows maxima at 8 a. m. and 7 p. m., and minima at 6 a. m. and 10 p. m., the a. m. minimum being the lower in this case. The curve for July shows maxima at 6 a. m. and 10 p. m., and minima at 4 a. m. and 12 noon, the noon minimum being by far the lower.

Careful examination of the vapor pressure data for the different stations given in Table 4, SUPPLEMENT 6, brings out the following facts:

At Boise, Idaho, from March to September, the lowest vapor pressure values are at 4 or 6 p. m., the highest temperature occurring at those hours. At Burlington, Vt., from May to September, there is a slight fall, or secondary minimum of vapor pressure, at noon or 2 p. m., the highest temperature being at 2 p. m. At Fresno, Calif., the primary minimum of vapor pressure from March to October occurs at 6 p. m., the highest temperature being at 4 p. m. The afternoon minimum in July is particularly well marked, the vapor pressure ratio at 10 a. m. being 1.212, and at 6 p. m. 0.917. At Chicago, Ill., there is a weak secondary minimum at 2 or 4 p. m., from June to September, the highest temperature being at 2 p. m.

Grand Rapids, Mich., shows minima at noon or 2 p. m. from May to September, the minimum in July being lower than the night minimum. The highest temperature occurs at 2 p. m. St. Louis, Mo. shows a very faint secondary minimum in June and August at 4 or 6 p. m., the highest temperature being at 4 p. m. San Francisco, Calif., shows the primary minimum at noon in September, October, and November, with the highest temperature at noon or 2 p. m. September and October at San Francisco have higher temperatures than June, July, or August. Sheridan, Wyo., shows a secondary minimum at 2 p. m., May to October, the highest temperature being at 2 or 4 p. m. Springfield, Ill., shows a secondary minimum at noon or 2 p. m. in June and July, the highest temperature being at 2 p. m.

Columbus, Ohio, alone, of the 10 stations given shows no trace of an afternoon minimum of vapor pressure in any month.

Complete data are not available for the other Florida stations, but the vapor pressure ratios for the noon observations of the year 1918 are below unity in many cases (Table 2), indicating a midday or afternoon minimum.

Although evaporation is most rapid during the middle of the day, it would seem that there is a general tendency toward a minimum of vapor near the time of maximum temperature, especially during the warmer months of the year, but the question is much complicated by evaporation and variations in wind velocity and direction, so that the afternoon minimum is often reduced, obliterated, or even turned into a maximum.

The only thing that could cause an actual decrease in the total amount of vapor in the air during the middle of the day is cloudy condensation, which is most active at that time. But this would be a very small factor.

Vapor pressure normally decreases with increase in altitude rather rapidly. (MONTHLY WEATHER REVIEW, March, 1919, p. 160.) During the heated portion of the day, especially in the warmer months, convection is quite active, and results in mixing the surface air with the drier air above. This mixing also brings down with the air from above, some of the momentum of the upper-air currents, and results in higher wind velocity during the day, and a turbulence of the atmosphere. This mixing by convection and turbulence is probably the true reason for the depression of the vapor pressure in the middle of the day. Observations aloft would probably show a rise in vapor pressure in the middle of the day, just as the wind velocity aloft is diminished thereby.

INTENSE RAINFALL AT DUBUQUE, IOWA, JULY 9, 1919.

Mr. J. H. Spencer, meteorologist, in charge of the Dubuque Weather Bureau office, has sent us an account of a very intense rainfall which accompanied a local thunderstorm July 9, 1919. In spite of the intensity of the rainfall, "thunder and lightning were rather less severe than in some of the storms of the past eight years," and the wind velocity was light.

"At no time during the hours that preceded the period of heaviest rainfall was there much indication of a severe storm, although the weather in the morning quickly changed to warm and sultry. Rain began as a light thundershower from 10:25 a. m. to 10:55 a. m. (ninetieth meridian time). Rain began again at 11:15 a. m. and was moderately heavy until 1:50 p. m. (the total to this time exceeding 1 inch). Then followed the great downpour of 2.64 inches in 45 minutes from 1:51 p. m. to 2:36 p. m.

"The following table gives the heaviest rainfall in periods of 5 minutes, 10 minutes, 15 minutes, 30 minutes, 1 hour, and 2 hours for a number of storms. It shows how much heavier was the rainfall on July 9, 1919, within a 1-hour period, than during any storm at Dubuque in recent years:"

Storm of—	5 minutes.	10 minutes.	15 minutes.	30 minutes.	1 hour.	2 hours.	24 hours.
July 4–5, 1876						[1] 4.55	4.55
Aug. 10–11, 1911	0.32	0.52	0.62	0.81	1.12	1.97	3.75
Aug. 18–19, 1912	.50	.71	.94	1.46	1.95	2.62	5.23
Aug. 31–Sept. 1, 1914	.41	.72	1.03	1.30	1.68	1.98	3.18
Sept. 14–15, 1914	.34	.51	.58	.73	.85	1.26	3.38
Sept. 25–26, 1915	.34	.46	.53	.68	1.27	2.23	4.79
Aug. 16–17, 1918	.35	.62	.79	1.37	2.10	2.96	5.22
July 9, 1919	.80	1.20	1.52	2.23	2.70	3.03	3.87

[1] 2 hours 5 minutes. 40 persons were drowned as the result of this storm.

Figure 1 shows the intense rainfall of July 9, 1919 (dotted line), in relation to other excessive rates in the North Central States plotted by Prof. A. N. Talbot.[1]

[1] Rates of maximum rainfall, Technograph No. 6, University of Illinois, 1892, 15 pp., incl. 8 diagrams.

The dashed curve A represents rates of rainfall which are rarely exceeded in the eastern United States. Its equation is $y=6.0/(x+.5)$, where y is the rate of rainfall in inches per hour for the time x expressed in hours. Curve B expresses the rate of frequent occurrence: $y=1.75/(x+.25)$.

"It is worthy of note that at Dubuque during the past nine years (1911 to 1919, inclusive) there have been seven storms in which more than 3 inches of rain within 24 consecutive hours fell, or more storms of similar intensity than occurred during the 29-year period from 1882 to 1910, inclusive, which gave only six. On the other hand, during the eight-year period from 1874 to 1881, inclusive, there were nine storms that gave more than 3 inches of rain within 24 consecutive hours."

An account of the seven lives lost and the $125,000 damage by the freshet resulting from this excessive rainfall will be found below on page 506 in the river and flood section.—*C. F. B.*

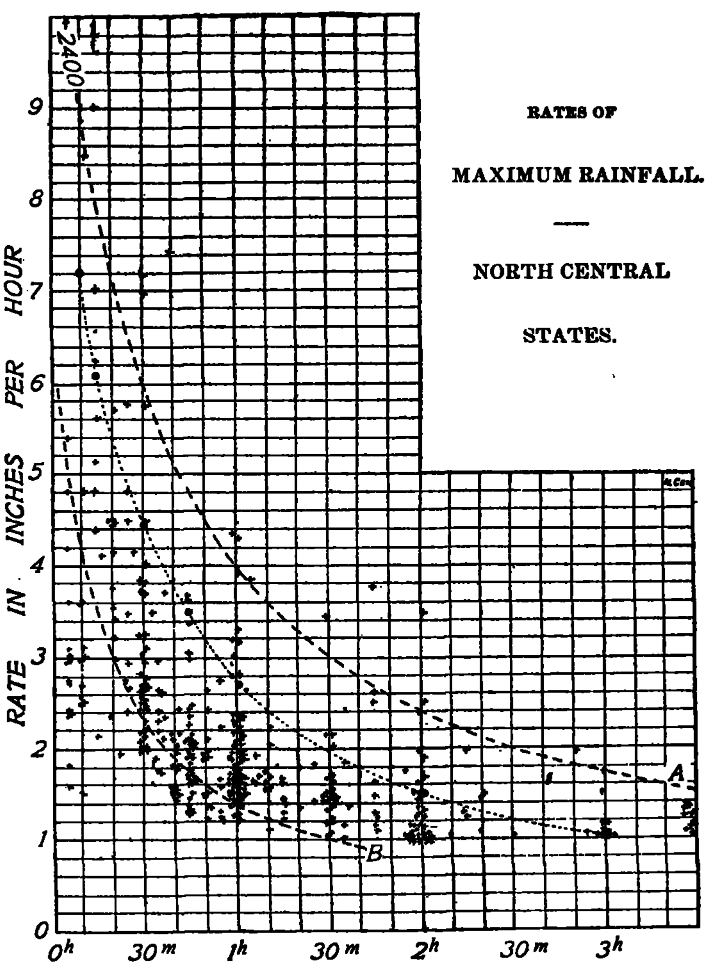

FIG. 1.—Excessive rainfall at Dubuque, Iowa, July 9, 1919, dotted line, compared with other excessive rates in North Central States. Compiled by A. N. Talbot.

HEAVY RAINS AT TAMPICO, MEXICO, JUNE 29–JULY 5, 1919.

By S. A. GROGAN.

[Dated Tampico, Tamaulipas, Mexico, July 7, 1919.]

During the week of June 29 to July 5, inclusive, more rain fell at Tampico than during the entire first six months of the year. From 6:30 a. m. on the 29th to 6:30 a. m. on the 5th a total precipitation of 15.64